Indigenous Peoples' Food Systems and Biocultural Heritage: Addressing Indigenous Priorities Using Decolonial and Interdisciplinary Research Approaches

Krystyna Swiderska [1,*], Alejandro Argumedo [2], Chemuku Wekesa [3], Leila Ndalilo [3], Yiching Song [4], Ajay Rastogi [5] and Philippa Ryan [6,*]

1 International Institute for Environment and Development, London WC1V 7DN, UK
2 Swift Foundation and Asociacion ANDES, Santa Fe, NM 87508, USA
3 Kenya Forestry Research Institute, Wundanyi 80304, Kenya
4 Farmer Seed Network, Nanning City 530000, China
5 Lok Chetna Manch, Ranikhet 263645, Uttarakhand, India
6 Royal Botanic Gardens, Kew, London TW9 3AE, UK
* Correspondence: krystyna.swiderska@iied.org (K.S.); p.ryan@kew.org (P.R.)

Abstract: The food systems and territories of Indigenous Peoples sustain much of the world's biodiversity, cultivated and wild, through agroecological practices rooted in Indigenous cosmovision and cultural and spiritual values. These food systems have a critical role to play in sustainability transformations but are widely threatened and have received limited research attention. This paper presents the results of four virtual workshops with Indigenous Peoples: a global workshop and local workshops with communities in coastal Kenya, northeast India and southwest China. Indigenous participants highlighted the role of their food systems in resilience to climate change, nutrition, sustainability and resilience to pandemics, and threats from agriculture, development and conservation policies. They called for research on the rapid loss of Indigenous knowledge; Indigenous Peoples' land rights and food sovereignty; and the impacts of industrial agriculture on Indigenous food systems, stressing the need for decolonial approaches to revitalise Indigenous knowledge. The paper presents a decolonial and interdisciplinary framework for action-research on Indigenous food systems past and present, from farm to plate, drawing on the virtual workshops, Andean decolonising methods and historical approaches. It concludes that decolonising action-research, led by Indigenous Peoples, is urgently needed to reverse the rapid loss of food-related biocultural heritage.

Keywords: indigenous peoples; biocultural heritage; indigenous food systems; traditional crops; climate resilience; decolonizing action-research; indigenous cosmovision; interdisciplinary approaches

1. Introduction

Indigenous Peoples' food systems have been described as those "integral to the cultural food use patterns of Indigenous Peoples" [1] and include socio-cultural meanings, practices and techniques, from seed selection to cultivation, harvesting, storage, processing, preparation and cuisine [2]. According to the FAO White Paper on Indigenous Peoples' food systems (prepared for the UN Food Systems Summit, 2021), Indigenous Peoples' view of life and knowledge systems have a critical role to play in food system sustainability transformations, complementing scientific knowledge [3]. Indigenous Peoples' food systems provide alternative regenerative, circular models which are vital for feeding humanity sustainably [3,4]. They have sustained the well-being of Indigenous Peoples and a balanced relationship with the natural environment for millennia [5]. Indigenous food systems are inextricably connected to land, self-determination, livelihoods, health, cultural and spiritual heritage [5] and conserve much of the world's biodiversity, cultivated and wild [6]. Processes of domestication and selection that began 4000–12,000 years ago have generated

a wealth of "food-related biocultural diversity"—in the form of crops and livestock and associated knowledge on their cultivation and use [7,8].

Indigenous and traditional peoples maintain the longest ongoing human experiences with providing food under environmental change [7]. Their diverse Indigenous and landrace crops and livestock species collectively tolerate a range of environmental stresses and are frequently more resilient, nutritious and sustainable than modern high-yielding varieties, requiring fewer external inputs [9–11]. Indigenous and traditional food systems have also generated a wealth of agroecological and regenerative practices, underpinned by Indigenous philosophies, values and beliefs that promote balance with nature [12,13]. Studies have shown that cultural values, festivals and beliefs play a key role in ensuring the continued consumption and production of diverse traditional foods, while traditional ecological values are transmitted through subsistence activities [2,10,14,15]. Many studies have shown the benefits of Indigenous and traditional foods for food security and dietary diversity [3,10]. The few studies to date analysing nutrition have shown a higher nutrient intake from traditional than modern diets—from the Artic and Alaska, to Peru, India and Botswana [16].

Despite their critical importance, the food systems, crops and knowledge systems of Indigenous and traditional peoples are often perceived as "backward" or unproductive [2] and are threatened by the industrialisation of agriculture and food, economic development and globalisation, leading to widespread losses of food-related biocultural diversity in many countries [3,5,7]. The modernisation of agri-food systems has helped reduce undernutrition but has not resolved persisting micronutrient deficiencies and has contributed to rising obesity and other diet-related diseases while being one of the most significant drivers of environmental degradation, biodiversity loss and climate change [6,7]. Indigenous Peoples are disproportionately affected by hunger and malnutrition, with women and girls suffering the greatest burden, due to structural inequalities that result in lack of access to land and other threats to Indigenous food systems including environmental degradation [5].

Indigenous and traditional food systems and crops have received far less research attention than their modern equivalents, and many non-commercial subsistence crops have been overlooked [17]. This paper aims to further understand the role of Indigenous food systems in food security, resilience and sustainability, the research priorities of Indigenous Peoples, and decolonial and interdisciplinary approaches for protecting and revitalising Indigenous food systems. It presents the results of a series of virtual workshops where Indigenous experts played a central role, held in 2020–2021 as part of the project "Indigenous Food Systems, biocultural heritage and agricultural resilience" funded by UKRI GCRF via the Arts and Humanities Research Council (AHRC): a global workshop and "local" workshops in coastal Kenya, northeast India and southwest China. This paper also presents a framework for decolonial and interdisciplinary research on Indigenous food systems past and present, from farm to plate, which can inform the design of future research and equitable partnerships. The framework is based on the AHRC workshops and also draws on the decolonising action-research approach used in the Potato Park, Peru [18], and interdisciplinary research on Nubian crops and food systems past and present [19,20], integrating ethnobotany, oral histories and archaeobotany.

Decolonial research approaches can revitalise Indigenous knowledge, address the threats and structural inequalities that underlie the loss of traditional food systems and lifestyles (e.g., loss of land and resource access) and generate strategies to leverage change [5]. They are shaped by Indigenous Peoples' struggles to resist and survive the assault on their culture; target local phenomenon instead of using theory from the west to identify a research issue; and create locally relevant constructs, methods and theories derived from local experiences and Indigenous knowledge [21]. They aim to promote Indigenous self-determination, values and beliefs as a way of resisting dominant discourses [5,22]. They seek to undo colonisation and "coloniality"—long-standing patterns of power that emerged out of colonialism but continue to define culture and knowledge production well beyond colonial administrations [23]. They begin with critiques of colonial relations in past research

involving Indigenous Peoples and aim to ensure that research can be more respectful, ethical, sympathetic and useful [24]. Gender is understood through an Indigenous cultural lens, for example as gender balance and complementarity (or duality) rather than gender equality, recognising that Indigenous societies were often not "oppressively patriarchal prior to the experience of colonialism" [5]. A holistic and interdisciplinary approach linking crops, wild foods, cuisine and cultural and spiritual heritage, past and present, is also needed to effectively protect and revitalise Indigenous food systems [2]. Research to date has tended to remain within disciplinary and sectoral silos, using very different approaches, and focusing on elements of food systems rather than whole food systems from production to consumption.

Research and policy have also tended to treat the cultural and biological heritage embedded in Indigenous food systems separately. Section 2 of this paper introduces the concepts of biocultural heritage and food-related biocultural heritage and contrasts Indigenous and Euro-western definitions of biocultural heritage. Section 3 describes the methodology, notably the series of virtual workshops with Indigenous Peoples. Section 4 explores the role of Indigenous food systems in climate resilience, sustainability, food security, nutrition and resilience to pandemics, the threats they face and Indigenous Peoples' priorities for research. It proposes a framework for decolonial and interdisciplinary research on Indigenous food systems and biocultural heritage, past and present, from farm to plate. The paper concludes that there is an urgent need for research to protect Indigenous food systems and biocultural heritage, using a decolonial approach that reverses the historical marginalisation of Indigenous knowledge and an action-oriented approach that strengthens local capacity and institutions and supports strategies to secure rights to land and self-determination, such as biocultural heritage territories.

2. Biocultural Heritage: A Holistic Food Heritage Framework

The concept of "food heritage" has tended to emphasise traditional practices, knowledge and celebrations [12] and the importance of intangible aspects such as food memories and identities [25], without specific reference to the related biological heritage of Indigenous and traditional peoples, such as traditional crops and livestock breeds and biodiversity-rich food producing landscapes [7]. Indigenous Peoples, on the other hand, have emphasised the inextricable linkages between their cultural and biological heritage [25]. The concepts of "biocultural heritage" and "food-related biocultural heritage" reflect these linkages, providing holistic decolonial frameworks for understanding and revitalising Indigenous and traditional food systems [2,26]. "Biocultural heritage" explicitly recognises the tangible biological components of Indigenous Peoples' food heritage—crop varieties, livestock breeds and landscapes created and conserved over generations, the intangible cultural and spiritual components and the links between them. "Food-related biocultural heritage" can be understood as encompassing heritage across the food system from production to consumption—including traditional seeds, crops, livestock, wild foods and landscapes, and related knowledge, practices, tools, celebrations, values and beliefs for cultivation, harvesting, hunting, processing, storage, preparation and cuisine.

The terms "biocultural heritage" and "biocultural diversity" have increasingly featured in conservation and heritage discourse, bridging the natural and social sciences and highlighting the role of Indigenous and traditional peoples and subsistence landscapes in conserving biodiversity [27–30]. In contrast to western conservation paradigms that separate people and nature [31,32], these concepts promote recognition of Indigenous and traditional peoples' rights and responsibilities over their ancestral lands, biodiversity and food heritage [27,28].

A number of definitions of "biocultural heritage" have emerged in recent years. In 2005, a group of Indigenous and non-Indigenous researchers defined "Collective Biocultural Heritage" as follows based on a proposal by Quechua leader Alejandro Argumedo (Asociación ANDES Peru): "Knowledge, innovations and practices of Indigenous Peoples and local communities which are often collectively held and are inextricably linked to

traditional resources and territories, including the diversity of genes, varieties, species and ecosystems, cultural and spiritual values, and customary laws shaped within the socio-ecological context of communities" [33]. This definition reflects the holistic worldview of Indigenous Peoples, where intangible knowledge and cultural values and tangible biological heritage and landscapes are interdependent and cannot be separated. It is based on long-term ethnographic observation and decolonial research with Quechua communities in the Potato Park, Peru and draws on a wide range of Indigenous epistemologies. Research with 11 Indigenous and tribal groups in five countries—Quechua (Peru), Kuna and Embera-Wounaan (Panama), Maasai and Mijikenda (Kenya), Lepcha, Limbu, Yanadi and Adhivasi (India) and Zhuang and Yan (China) identified multiple interlinkages and interdependencies between the components of biocultural heritage as complex adaptive socio-ecological systems, which, together, sustain resilient food systems and local economies [33].

This definition of biocultural heritage incorporates language from the Convention on Biological Diversity, which the research sought to inform. By recognising traditional knowledge, cultural values, biodiversity and landscapes as inextricably linked heritage, it asserts Indigenous Peoples' rights over biodiversity and territories. The idea of an "inextricable link between cultural and biological diversity" first arose in the 1988 Declaration of Belem at the first International Congress of Ethnobiology in Brazil, which directly involved Indigenous and traditional peoples [30]. Biocultural heritage encompasses memory, language, history, practices, values and ways of life within a particular territory and ecological context [31]. Similarly, Virtanen (2019) understands the "biocultural heritage" of the Apurinã people in Brazil "in the context of relational ontologies, in which nonhuman entities and the natural environment cannot be separated from being a human". "Apurinã biocultural heritage is holistic and involves diverse cultural, ecological, spiritual and economic aspects and knowledge", it is about "past and future generations that are both linked in the present" [34].

The above understandings of biocultural heritage developed with Indigenous Peoples reflect their holistic cosmovision, the inextricable linkages between biological and cultural heritage and the importance of spiritual beliefs [3,26,33]. By contrast, definitions developed by western academics reflect a more reductionist and positivist worldview. Ekblom et al. (2019) define biocultural heritage as consisting of four interactive elements that can only be understood through landscape analysis (an interdisciplinary toolbox): ecosystem memories (larger or "deep-time" practices shaping landscapes); landscape memories (smaller-scale practices and their biological and built outcomes); place memories (practices related to a specific place); and stewardship and change (building on local traditions, inclusivity and equity for sustainable development) [29]. Bridgewater and Rotherham (2018) offer a definition of "biocultural assets and heritage" as: "result from interactions between people and nature at a given time in a given place", for use in further academic work and especially in the work of global biodiversity policy processes [30].

In this article, we build on the concept of biocultural heritage developed by Asociación ANDES, IIED and Indigenous partners [2,14]. Since this concept emerged from Indigenous cosmovision and a process to assert Indigenous Peoples' rights to land and self-determination in the Potato Park, it provides a framework to confront the underlying structural threats to Indigenous food systems—the erosion of rights to land and the dominant agri-food model [5]. The concept provided the "original action-research framework guiding the Potato Park's work" which has revitalised a pre-colonial Andean food system that provides one of the richest in-situ genetic reserves in the world [7,26]. It provides a flexible framework that can be adapted and expanded to reflect key elements of food heritage from production to consumption. However, it is not a substitute for Indigenous Peoples' own philosophies that underpin their food heritage. For example, the Andean Ayllu concept where three Ayllus or communities—the human and domesticated, the wild and the sacred—have to be in balance to achieve wellbeing (Sumaq Causay) [31] (Figure 1); and the Subak cooperative water management system in Indonesia, which is a

manifestation of the Tri Hita Karana Philosophy, which brings together the realms of the spirit, the human world and nature [12].
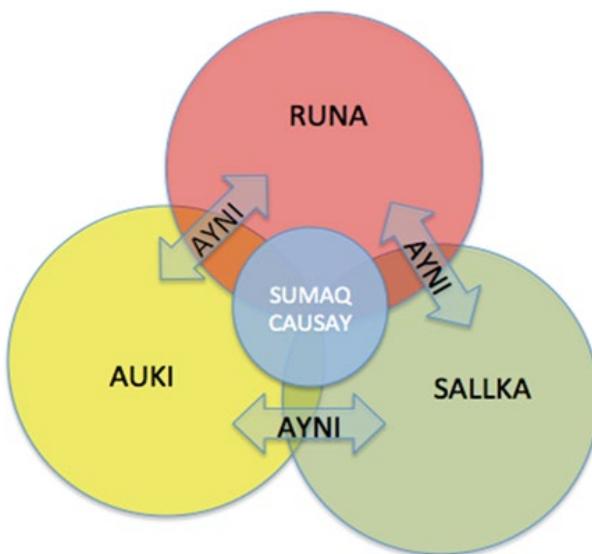
Figure 1. The Andean Ayllu concept of Holistic Well-Being. Runa Ayllu: humans and domesticated plants, animals, water, etc.; Sallqa Ayllu: wild plants and animals; Auki Ayllu: the sacred and the ancestors; Ayni: reciprocity.

3. Materials and Methods

The results are based on four virtual workshops held as part of the AHRC project development grant "Indigenous food systems, biocultural heritage and agricultural resilience", which sought to collaboratively design new interdisciplinary and decolonial approaches to explore Indigenous Peoples' food systems past and present, from farm to plate. The workshops brought together Indigenous representatives from several regions, Indigenous and traditional communities from Kenya, India and China, action-researchers working on biocultural heritage and UK humanities experts. They were held virtually due to the COVID-19 pandemic.

First, a global workshop was organised by IIED and RBG Kew in October 2020, on "Indigenous food systems, biocultural heritage and the Sustainable Development Goals (SDGs): Challenges, interdisciplinary research gaps and empowering methodologies" [2]. The workshop consisted of four webinars (each 2–3 h), which involved a mix of pre-prepared presentations, panel discussions and free-form discussions, with at least 50% of presentations in each webinar given by Indigenous Peoples:

- Webinar 1 "Opening keynotes and Potato Park (Peru)" (9 October) explored the role of Indigenous food systems and crops in climate resilience, sustainability, nutrition, health and well-being, key trends and challenges and responses needed. The webinar entailed presentations by Indigenous experts from the Philippines, Kenya, FAO and Centre for Indigenous Nutrition and Environment (CINE), and a live-streamed session from the Potato Park biocultural territory where Quechua community experts (researchers, elders, women, youth) presented their Andean food system using a traditional story-telling format.
- Webinar 2. "Indigenous food systems in China, India and Kenya" (13 October) explored the same issues as webinar 1, focusing on the Rabai Mijikenda community in Kenya, Lepcha and Limbu communities in northeast India and Naxi and Moso in Southwest China, with presentations by local researchers and Indigenous elders and community researchers.

- Webinar 3. "Co-creating research agendas" (14 October) explored Indigenous Peoples' research priorities relating to their food systems, including key issues and challenges, research approaches, the role of academics and interdisciplinary research gaps.
- Webinar 4. "Exploring research methods" (15 October) involved presentations on interdisciplinary research methods by academics; and on decolonising action-research methods by Indigenous experts from Peru, the Philippines and Botswana.

The global workshop was attended by over 130 participants, including 28 Indigenous representatives from Asia, Africa, Latin America and the Arctic, 52 academics and four UN agencies (including FAO Indigenous Peoples Unit). Indigenous presenters included Quechua people from the Potato Park (Peru), and representatives of Mbororo pastoralists (Chad), Kankanaey and Ibaloi (Philippines), Khasi, Lepcha and Limbu (India), Tharaka and Mijikenda (Kenya), Bantu (Botswana), Naxi (China) and Yukaghir (the Arctic, Russia). The perspectives of hunter-gatherers were reflected by a researcher with long-term fieldwork experience in tropical forests of the Congo Basin, Sumatra and Borneo.

Three local workshops were then held virtually with Indigenous and traditional communities in Kenya, India and China, from January to March 2021. The workshops explored traditional food systems, crops and biocultural heritage, their roles in food security and resilience, the threats and challenges they face and ways forward. They identified key issues for research and research approaches, as the basis for developing a decolonial and interdisciplinary research framework and funding proposal. Each workshop engaged 20–30 community members, along with 3–4 UK researchers and 2–3 local research partners, in a 4-h webinar live-streamed from the community landscapes in Kenya and China and a local town in India (due to connectivity issues):

- Rabai (a Mijikenda sub-tribe) sacred Kaya forest landscape in coastal Kenya;
- The Stone Village in Yunnan (China) where four Naxi and Moso communities gathered; and
- Kalimpong in northeast India where two Lepcha and Limbu communities gathered (Lingsey and Lingseykha).

The local workshops consisted of pre-prepared presentations by different community members—including community researchers, elders, women and youth—followed by questions and discussion. As with the Potato Park session, the workshops were largely designed by communities and local partners and each started with a traditional ceremony or prayer reaffirming the importance of cultural and spiritual values related to landscapes, food and biodiversity. The travel budget for the workshops was used to purchase equipment needed for live-streamed interactions from the field with good visual and sound quality (using Zoom Meetings). The results of the virtual workshops were used to develop a broad framework for decolonial and interdisciplinary research on Indigenous food systems past and present, from farm to plate.

4. Results

4.1. Global Workshop on Indigenous Food Systems, Biocultural Heritage and the SDGs

4.1.1. Role of Indigenous Peoples' Food Systems in Food Security, Resilience and Sustainability

Indigenous representatives from different regions stressed the importance of their ancestral food systems and biocultural heritage, based on centuries of accumulated wisdom, for food security and sovereignty, cultural identity, spirituality, health and wellbeing, environmental stewardship and climate resilience. Their food systems are diverse, entailing farming, shifting cultivation, pastoralism, hunting and gathering, and fishing practices and foodways, adapted to often harsh environments. However, they share a number of common features that underpin their role in sustainability and food security:

Rich Biodiversity, Agroecology and Cultural Heritage

Indigenous food systems maintain balance with fragile environments [4]. They typically sustain high levels of biodiversity, including underutilised crops, wild foods, medicinal plants and crop wild relatives. The use of well-adapted Indigenous crop varieties and

landraces, along with traditional agroecological practices (e.g., intercropping, agroforestry), reduces the need for chemical inputs and promotes efficient use of natural resources and conservation of biodiversity. In Rabai for example, over 60 different varieties of food plants are used, including 21 Indigenous vegetables, 25 wild fruits, and 15 Indigenous crops (e.g., cowpeas, sorghum, millet) and landraces (eg. cassava and maize). Farmers have developed a cowpea variety that is high-yielding and pest and disease and drought tolerant by crossing varieties from farms and forests. The Lepcha and Limbu in northeast India grow about 50 different crops and have knowledge of 36 wild edibles and 38 medicinal plants. In many Asian communities, home gardens play an important role in sustaining heritage varieties and semi-domesticated foods for cultural use, nutrition and medicine. Even shifting cultivation, often perceived as a driver of deforestation, is in fact a sustainable practice [4]. Rituals are integral to Indigenous farming and food systems in the Peruvian Andes, sustaining ecological values. Farming rituals are also practiced by Lepcha and Limbu farmers in the Indian Himalayas, where most households maintain biodiverse home gardens which are considered sacred, and by Naxi-Moso in northwest Yunnan - in Wumu Village (China) "worship is around maize, rice and other food crops and medicinal plants" (Jixian He, Village Elder). In Rabai, elders conserve sacred Kaya forests important for food and climate resilience.

In the Potato Park, ancestral principles of Solidarity, Reciprocity and Balance between the human, natural and sacred worlds, define how agriculture is practiced and ensure an abundance of food, "this diversity of food could not exist without these principles and without women" who play a key role transmitting them to younger generations (Mariano Sutta, community researcher). The Potato Park biocultural heritage territory, which is collectively governed by six Quechua communities, conserves one of the highest levels of potato diversity in the world—with 1347 native varieties, according to traditional classification (Nasario, community researcher)—and a wealth of other Andean crops, livestock and wildlife [30]. Here, farmers have been dealing with potato blight for millennia and know how to manage it using natural methods (seed selection and crop rotation). In the Potato Park and Lepcha and Limbu communities, wildlife signals are still used to guide farming activities and major farming activities are collective.

For the Tharaka in Kenya, seeds are sacred and "very important for cultural identity and spirituality" (Simon Mitambo, Tharaka leader). In some cases, spirituality still governs daily life and livelihoods, for example through spiritual leaders (Dongba) in Yumu Village, a remote Moso village in Yunnan (near Tibet), and mountain gods that play a key role in governance in the Potato Park. However, traditional values and food systems are changing in many Indigenous communities due to modernisation, particularly amongst younger generations and in less remote communities.

Climate Resilience and Adaptation

Indigenous food systems are a key part of the solution to climate change [4]. Maintaining a diversity of crops reduces risk and enables adaptation to climate change, for example in semi-arid coastal Kenya and in the Potato Park in the high Andes. In the northeast Indian Himalayas, hardy local landraces of maize, millet, rice, buckwheat and naked wheat safeguard against crop failure and dryland paddy can still be found in some villages. Traditional farmers in Peru, India, the Philippines and Kenya continue to use crop wild relatives, which contain important resilience traits, to fortify domesticated crops. As Lino Mamani, a Potato Park community researcher explained "we combine them [wild potatoes] with domesticated potatoes so they can converse". In the Philippines and northeast India, wild plants are cultivated in home gardens to enrich domesticated populations. "People have an intrinsic habit of trying out and conserving new species in their back gardens which act as a traditional germplasm collections" (Nawraj Gurung, Lok Chetna Manch).

Food Security and Nutrition

Indigenous food systems are often viewed as having low productivity, but many are already achieving Zero Hunger, while "current food systems will not be able to feed humanity sustainably unless they are reinvented with much stronger environmental considerations" (Yon Fernandez-de-Larrinoa, FAO). Indigenous food systems seek to ensure food security for future generations, for example through "seven-generation thinking" in Chad and China. A study in Inuit communities in the Artic found that more protein and nutrients are consumed with traditional foods compared to modern foods and that traditional foods provide Vitamins C and A (Harriet Kuhnlein, CINE). In Yakutia in the Russian Artic, poor nutrition and lack of vitamins and minerals associated with a shift to cooked modern diets have caused many diseases for Indigenous Peoples (Vyacheslav Shadrin, global workshop). In the Potato Park, women know about the health benefits of native crops and medicinal plants, "we provide medicine to our kids through food" (Ricardina, Potato Park); and only native crop varieties are planted because "modern varieties don't produce well". In Lepcha and Limbu communities in northeast India, more than 80% of diets consist of locally grown crops and livestock.

Resilience to Pandemics and Economic Development

COVID-19 has highlighted the vulnerability of global food chains and the resilience of localised Indigenous food systems. "During the pandemic, there was not much shortage of food in Lepcha and Limbu villages, in fact, people were growing more and eating more healthy food" (Nawraj Gurung, Lok Chetna Manch). "Despite COVID-19, we have plenty of food—the Potato Park has donated a ton of potatoes to people in need in Cusco" during the pandemic, based on the ancestral principle of Solidarity (Aniceto, community researcher). For the Tharaka people in Kenya, traditional seeds are sacred and play a central role in cultural identity and spiritual well-being. As Simon Mitambo, Tharaka leader explained "we need Indigenous seeds for cultural ceremonies, and when preparing to plant, certain rituals must be performed to receive the gift of nature (rain). Most of the work on Indigenous food systems and seeds is collective and so brings cohesion to the community. During COVID-19, Indigenous seeds helped us to support one another". Indigenous food systems can also make important contributions to economic development and employment. Pastoralism contributes about 40% of the national GDP in Chad (Hindou Ibrahim, Mbororo, Chad). The Potato Park supports a number of collective micro-enterprises led by women (e.g., ecotourism, gastronomy).

4.1.2. Threats to Indigenous Peoples' Food Systems

The workshop identified multiple threats facing Indigenous food systems, including industrial development, modernisation, western education systems, urbanisation and protected areas. Industrial agriculture and modern foods have had significant adverse impacts; "the full impact of industrial agriculture at local level is not yet fully appreciated by national policy makers who are eager to simply monetise agriculture" (Phrang Roy, India). In Asia, commercial crops and plantations have replaced traditional farming in many Indigenous communities, leading to the devaluation and erosion of Indigenous and local knowledge, degradation of rice terraces, shrinking of swidden farming areas and rapid changes in food, diets and nutrition. In Northern Thailand, for example, cash crop expansion promoted by the government has had serious impacts on traditional agriculture, particularly, rotational farming, and "has destroyed forests and caused soil erosion and pollution from pesticides and herbicides" (Joji Carino, the Philippines). Modern education has impelled young people to migrate to urban areas to study and work, losing their cultural roots and identity. In northern Yunnan, with the influx of modern seeds, cash crops and foods, Naxi food systems have become increasingly uniform, "diversity is disappearing in food crops and ways of preparing them, and this threatens the whole Indigenous food system. Before, food was for livelihoods and nutrition, and now, it is for money so that is why diversity is declining". (Haimei Liang, Naxi, Wumu Village leader). In Lingsey and

Lingseykha, Kalimpong District, northeast India, some traditional foods have been lost due to the influence of town and city food and aggressive food marketing. Traditional rice cultivation is decreasing because of the Green Revolution and some traditional crops have been lost (e.g., dryland paddy and foxtail millet). Restrictions on forest use have promoted a shift to cash crops.

Similarly, agricultural modernisation and commercialisation in Africa have weakened and eroded Indigenous food systems. In Kenya, "there has been a big push to promote hybrid seeds and chemicals which undermine soil and water; colonial seed and intellectual property laws threaten collective Indigenous seed systems; and the influence of multinational corporations means it is not possible to promote laws that support Indigenous food systems" (Simon Mitambo, Tharaka leader). In Rabai, industrial development has reduced land for farming, reducing crop diversity and urbanisation, modernity, Christianity, proximity to Mombasa and youth outmigration are rapidly eroding cultural practices and beliefs, weakening social cohesion. The Potato Park communities have protected their land against mining by establishing a collectively governed biocultural heritage territory and registering it as an "Agrobiodiversity Zone", but still face threats from mining and Genetically Modified Organisms (GMOs) - "we have to protect our lands from genetic contamination, and privatisation of seeds" (Ricardina, Potato Park community researcher). Climate change also threatens the diversity of potatoes "all crops are moving up the mountain so we are losing varieties in the upper part".

In the Russian Artic, the loss of Indigenous territories due to various types of industrial development has almost destroyed a traditional hunting and fishing culture which is very close to nature and has led to severe environmental degradation, "the main challenge facing us is the loss of our lands; the way out of the extinction situation facing northern peoples is to return to our former economic structure and traditional food culture" (Vyacheslav Shadrin, Yukaghi). In Chad, the Mbororo are transboundary people and pastoralism is "a sustainable land-use system because not all land can have cattle; but land that is vital for pastoralist people is being sold off to sedentary people, and there are transboundary issues impacting our food system and food sovereignty" (Hindou Ibrahim, Mbororo). Hunter-gatherers in tropical forests are very culturally diverse but highly vulnerable, often deprived of their right to self-determination and "forced to give up a way of life that most authorities consider to be non-decent" (Edmond Dounias, French Research Institute for Sustainable Development). They are victims of both the economic destruction of forests and forest conservation policies that prohibit the use of essential resources.

In Thailand, Indigenous farmers can be imprisoned for rotational farming because of a misconception in forest science that it causes deforestation, and forest laws do not recognise the rights of Indigenous Peoples living in protected areas. However, a cabinet resolution on recovering Karen livelihoods has recognised the traditional and dynamic practice of rotational agriculture and its co-existence with the natural ecosystem (Joji Carino, the Philippines). The resolution promulgates Special Cultural Zones for the revival and maintenance of cultural identity, in harmony with nature. Revitalising rotational agriculture has strengthened the local economy, and some young people have returned to their communities to reclaim their cultural identity and alternative livelihoods. These innovations in rotational farming combined with social enterprise development provide a new and increasingly popular solution for young people.

4.1.3. Indigenous Peoples' Research Priorities

Several Indigenous representatives at the global workshop stressed that research should focus not only on their food systems but on the threats and challenges they face. They highlighted three key issues requiring further research: the rapid loss of Indigenous knowledge, Indigenous Peoples' land rights and food sovereignty and the impacts of industrial agriculture on Indigenous food systems. They called on researchers and academics to:

- Fully engage Indigenous Peoples and support Indigenous-led research since conventional externally-led research is not useful to Indigenous Peoples and "scientists

can never fully understand Indigenous Peoples without actively engaging them in research" (Hindou Ibrahim, Chad).

- Respect the value of Indigenous knowledge and ancestral wisdom on the same level as science, and recognise Indigenous Peoples as equal experts.
- Mainstream the often overlooked Indigenous perspectives and knowledge in conventional research, and go beyond multidisciplinarity to take a multicultural approach that blends Indigenous knowledge and science.
- Develop culturally appropriate research approaches with Indigenous Peoples that support Indigenous methods of learning and knowledge transmission (e.g., storytelling, observation, landscape walks).
- Respect Indigenous Peoples' rights as enshrined in the UN Declaration on the Rights of Indigenous Peoples, including the right to Free Prior and Informed Consent at the community and individual levels, by providing full information about proposed research and allowing communities to deny consent or place conditions.
- Understand community decision-making processes and work with community institutions.
- Support power equalising approaches for Indigenous communities and women, including inter-community networking and meaningful engagement in policy processes.
- Contribute to the body of knowledge of Indigenous Peoples for their own needs, rather than as an object of investigation—research should facilitate learning and collective analysis within communities, and "the community should be the first to benefit from the knowledge produced" (Florence Daguitan, the Philippines).

Many Indigenous Peoples have started to revitalise their food systems, hence academics can expect Indigenous Peoples to do their own research based on Indigenous knowledge, and can provide complementary analysis, for example, on the nutritional value of Indigenous foods or methods for monitoring improved soil health—"there is a lot of scope for collaboration, provided scientists and Indigenous Peoples respect each other" (Florence Daguitan, the Philippines). A number of Indigenous representatives underlined the need for research to address Indigenous Peoples' problems, and take a decolonial approach—research should:

- Start by "decolonising the minds of Indigenous Peoples who have been brainwashed to think that their foods are inferior" (Bagele Chilisa, Botswana).
- "Debunk the notion that research is only done by the schooled" (Florence Daguitan, the Philippines).
- Use Indigenous research methods that frame research using Indigenous worldviews and values, recognising the spiritual values of food and links to land (Bagele Chilisa, Botswana).
- Use decolonising action-research methods where research is led by Indigenous elders and authorities (including women), and guided by Indigenous epistemic principles (e.g., relationality, reciprocity and balance with the natural world) (Alejandro Argumedo, Peru).

The importance of a "Multiple Evidence Base" approach was highlighted, where Indigenous and western knowledge is valued equally, objectives are set jointly, knowledge is created and validated within each knowledge system, and the results are shared, bridging knowledge systems. "This can create a richer picture, to discover new things that would not be discovered otherwise" (Pernilla Malmer, SwedBio at Stockholm Resilience Centre) [35]. The workshop also revealed differences in approaches to protecting threatened Indigenous knowledge and food heritage, with Indigenous Peoples prioritising protection for community-use and protection of rights, and non-Indigenous researchers prioritising global conservation goals. Documentation in ethnobotanical publications and public databases can be important to protect traditional knowledge and crops from loss. For example, landraces are being lost and are generally poorly documented and conserved ex-situ, hence their diversity and loss are not properly understood and they have been overlooked until recently. However, external documentation and publication may not directly benefit the communities whose knowledge is documented and can facilitate the misappropriation of traditional knowledge or "biopiracy" (i.e., unauthorised commercial

use). This is especially the case for medicinal plants and wild edible plants but generally less so for crops that tend to be less commercially sought, with some notable exceptions such as potatoes. In the Potato Park and Barter-Maize Park in Peru, communities have documented their Indigenous knowledge about wild foods and native crops in community biocultural databases, which protect traditional knowledge from loss while protecting community intellectual rights.

4.1.4. Decolonising and Interdisciplinary Research Methods

Indigenous experts presented effective Indigenous methods for research on agri-food systems. Florence Daguitan (Tebtebba, the Philippines) highlighted several tools:

- Mapping while walking through the territory to strengthen the sense of place and identity, and show the diversity of food crop varieties and animals breeds, locations of wild food plants and animals, and how the whole territory contributes to the diet. Communities can use GPS to construct a three-dimensional map and introduce some "modern ways" of biodiversity inventory.
- Traditional calendars to show the availability of different foods at different times of year, when to plant different crops, when not to disturb wild animals in the forest and fish in rice fields and rivers to give them time to mate and reproduce and indicators for changes in seasons.
- Story-telling to show how certain food is valued and why; changes in food production and consumption; and how wild areas are protected and seeds are conserved.
- Comparing and contrasting, for example, to show how community elders/leaders were more proactive in the past in investigating community issues and concerns and addressing these for the common good, abundance or scarcity of certain foods and health of the environment in the past and today.
- Learning by doing, for example producing organic farm inputs, conducting soil tests with scientists, using/testing traditional indicators, and introducing innovations in rice farming systems.
- Collective analysis of the results, which can lead to community policy formulation and action, for example, banning junk food from entering the community and restoring backyard gardens in every home.

Alejandro Argumedo (ANDES, Peru) presented a decolonising action-research approach developed with Quechua communities in the Potato Park, which has enabled them to maintain a very large collection of native potatoes. Any action has to be developed in line with Quechua learning principles of Yachay—knowledge learned through reflection, discussion and analysis; Llankay—practical learning; and Munay—learning with the heart. Decolonisation means leadership by elders and community authorities, and the participation of women and youth is key. Oral methods are used, but metrics are also traditionally used to create and store data, such as the Inca Khipus (knots tied on string) which has been used in the Potato Park to represent chromosomes in potatoes. Yupana, a matrix ranking tool of the Incas is used to prioritise different wild food and medicinal plants collected through participatory transect walks. Indigenous mixed methods research combines qualitative and quantitative approaches, responds to Indigenous wellbeing objectives (Sumaq Causay) and is guided by principles from the Incas. Indigenous methods used by the Quechua Potato Park and Barter-Maize Park communities promote Indigenous knowledge transmission from elders to youth. "We have developed visual ways to collect data, including a smartphone app that can use photo, video or voice recordings, which are tools for traditional knowledge transmission. The information collected with the app is automatically stored in a community database and is discussed by elders in knowledge circles. It is used to solve community problems such as pests and diseases, or child malnutrition, and to maintain balance among the three Ayllus. Then the community assembly sanctions the proposed actions and they become part of a Life Plan".

Non-Indigenous experts highlighted the need for interdisciplinary approaches since Indigenous food systems (IFS) and biocultural heritage span different disciplines. "Research

has tended to focus on elements within food systems—e.g., farming systems and crops, or foods and nutrition—rather than whole food systems from cultivation to cooking, including harvesting, storage, processing and preparation, and how they connect with material culture and intangible cultural and spiritual heritage" (Philippa Ryan, RBG Kew). Ethnobotany bridges traditional knowledge, humanities and natural science by focusing on the human uses of plants in their biocultural context. It can be used to document Indigenous food heritage, including wild foods and crops from farm to plate, linking crops, cuisine, values and beliefs, and traditional knowledge and western taxonomy, for community livelihoods and conservation.

Oral history, including stories and songs, can facilitate understanding of threatened or lost food heritage to inform community revitalisation efforts. It can generate insights into often overlooked cultural and spiritual meanings of traditional seeds, farming and food systems, over a significant historical duration. It can communicate food traditions and heritage and the meanings and feelings involved in a particularly vivid manner; and reclaim the voices and life experiences of Indigenous and subaltern groups such as women farmers, who are either not heard or marginalised in written documents. "Too often in development writings, the voices of subaltern groups tend to be subsumed by the researchers' interpretation which is what ultimately becomes authoritative" (S. Hazareesingh, Open University) [36]. Ethnobotanically-based oral histories can be useful for understanding crop and food histories and temporal changes [19,20]. Historical sources can also provide useful information about lost heritage, but Indigenous Peoples may not want to use colonial interpretations. In the Philippines where "all history is colonial", Indigenous Peoples in the Cordillera have used historical sources to "reinterpret it in their own way and revive their heritage" (Joji Carino, the Philippines). Archaeobotanical data can provide evidence of long-term cultivation of Indigenous crops and landraces, which used to be major but have become minor, and this can be used alongside evidence of present-day resilience to show the importance of traditional crops for local agroecological contexts [37,38].

4.2. Local Workshops in Kenya, India and China

The local workshops in coastal Kenya, the Indian Himalayas and southwest China enabled further understanding of the role of Indigenous crops and landraces in climate resilience, food security and health, and the challenges facing Indigenous food systems and ways forward, based on the knowledge of different community members (Table 1). In semi-arid Rabai, Kenya "Indigenous crops (e.g., cowpeas) are very resilient to drought and pests and diseases, and very nutritious, some are medicinal; we plant wild cowpeas from sacred Kaya forests on-farm for adaptation to climate change" (Salma, community researcher, Rabai). "Traditional foods and Indigenous vegetables are very important for increasing immunity and that prevents us from getting sick" including from COVID-19 (Daniel Garero, Kaya elder). Aggressive promotion of hybrids by extension services has led to erosion of hardy and nutritious Indigenous crops (e.g., cowpeas, sorghum, millets), while modern education and youth out-migration to cities have reduced the transmission of traditional food knowledge. This is compounded by industrial development (sand mining) causing crop failure due to "massive pollution in the river". Kaya forests traditionally provide an important source of wild foods and medicinal plants but are being degraded as Kaya elders are increasingly side-lined by youth influenced by modernisation.

In northeast India, forest conservation laws prohibit the Lepcha and Limbu customary sustainable use and agroforestry systems, following the establishment of Neora Valley National Park and Reserved Forest in Lepcha ancestral land. The communities link the declining productivity of traditional crops to declining soil fertility and a shortage of manure, as it is no longer possible to graze cattle in the forest to access quality fodder under large trees. Forest quality has also declined since lack of ownership and fear of being fined means communities are no longer conserving large trees and seeding the forest to protect the fragile Himalayan ecosystem. Expansion of protected areas is a growing problem for the livelihoods of hill tribes in the region.

Table 1. Key challenges facing Indigenous food systems in Yunnan China, northeast India and coastal Kenya and ways forward: Summary of global and local workshops.

Naxi and Moso (Northwest Yunnan, China)

Challenges

- Diversity of crops and ways of preparing them are disappearing, with the influx of modern foods
- Food crops are becoming more uniform as they are now grown more for market than for subsistence
- Need to conserve agrobiodiversity for health and climate resilience
- Loss of TK transmission and male outmigration are reducing labour and food self-sufficiency

Ways Forward

- Need to revitalise IFS and traditional culture and develop ways to pass down culture
- The four villages need to work together to help protect and revitalise their biocultural heritage through common rules and learning exchanges (e.g., on community seed banks and traditional Dongba culture)
- Need policy protection for intangible food and crop heritage
- Need participatory documentation of crop processing, seeds, wild foods, herbal medicines, traditional practices and culture, and oral histories.
- Need to develop links to markets and ecotourism (e.g., special local foods, handicrafts, trekking)

Lepcha and Limbu (Kalimpong, West Bengal, India)

Challenges

- The IFS is threatened by policies that restrict the use of forest resources (including the use of fodder, wild edible plants and other plant resources e.g. for making agricultural tools)
- Some landraces of traditional crops grown are still grown but are declining in yield—such as maize, paddy rice, finger millet, buckwheat, bread wheat and proso millet.
- Dryland rice, wild millets and foxtail millet have mostly disappeared because of Green Revolution methods and introductions of hybrid crops.
- Some traditional cuisines are declining, and are negatively impacted by modern food marketing
- Community seed-saving initiatives are in place but need more support
- TK about agrobiodiversity is declining with youth outmigration and modernization

Ways Forward

- Initiatives to promote traditional foods in markets and ecotourism
- Policy needs to protect the Indigenous cultures that maintain food diversity
- Crop diversity needs fuller documentation, including bean landraces (20+) which have not all been identified as species
- Rituals that sustain IFS need support

Mijikenda (Rabai, Kilifi county, Kenya)

Challenges

- Traditional farming, cultural practices and beliefs are diminishing very fast, due to proximity to Mombasa, youth outmigration and non-Mijikenda religions
- Loss of TK, reduced knowledge transmission between generations, marginalisation of Kaya elders and modern education (e.g., lack of integration of traditional foods in schools).
- High population density, limited land, climate pressures (increased drought) and mining pollution
- Some varieties of traditional crops, for example, sorghum, millet and yams, have been lost due to introduction of hybrids.

Ways Forward

- Help to conserve wild and domesticated Indigenous vegetables and wild fruits, which supplement farming and are important for nutrition and resilience to climate change.
- Strengthening collective governance structures (Kaya elders) for forest and landscape conservation
- Strengthening market links for Indigenous crops (e.g., cowpeas) and ecotourism to sustain cultivation
- Research on how modernity is affecting culture and knowledge transmission, links between loss of culture and Indigenous crops, role of women and girls in IFS, household consumption of Indigenous foods, traditional ways of preserving food, and how to propagate Indigenous foods.
- Promote benefits of Indigenous foods (health, climate, livelihoods etc.

Community members highlighted the need to protect and revitalise traditional crops, wild foods, medicinal plants, home gardens, inter-connected forest-farm-food systems and related cultural values and philosophies, for food security, resilience and income

generation. They stressed that future research should generate tangible livelihood benefits for communities, for ethical reasons and to engage youth, and should explore income-generating opportunities and support micro-enterprise development (e.g., for traditional crops, ecotourism, handicrafts). They also highlighted the need to continue the decolonial Potato Park approach (used in a previous project), where 1–2 community researchers are employed from each village to co-design, facilitate and conduct the research; and Indigenous research methods are used that promote transmission of Indigenous knowledge. This approach has strengthened community research capacity, inter-village networks and livelihoods [39–41].

4.3. Developing a Decolonial, Interdisciplinary Framework for Research on Indigenous Food Systems

The results of the global and local workshops were used to develop a broad framework for decolonial and interdisciplinary research on Indigenous food systems and biocultural heritage past and present, from farm to plate. Given the virtual format, it was not possible to engage in detailed discussions with communities on research questions, methods and tools. However, the framework addresses the priorities identified by communities in Kenya, India and China and can be used to inform future discussions with these and other communities. As highlighted by workshop participants, Indigenous Peoples should take the lead in designing or co-designing research questions, methods and tools, based on their own knowledge, theories and methods, to ensure an ethical and decolonial approach that revitalises traditional knowledge.

The research framework also draws on the Potato Park's decolonising action-research approach, integrating Indigenous research methods and tools. It aims to support community-led processes to establish biocultural heritage territories, building on the successful Potato Park. This collectively governed biocultural heritage territory has significantly increased native potato diversity; enhanced food security, nutrition and livelihoods despite severe climate change impacts; and strengthened Andean cultural and spiritual values that ensure the conservation of agrobiodiversity and ecosystems, restoring the dominance of Quechua religious festivals over Catholic ones [42]. The Potato Park provides a model for Indigenous self-determination, using agrobiodiversity to assert Indigenous expertise, traditions and rights [43]. The framework also integrates ethnobotany, oral histories and archaeobotany, building on research on Nubia crops and food systems past and present [19]. Historical approaches can facilitate understanding of lost and threatened heritage that communities may wish to revitalise to address present-day challenges and can generate evidence of long-term use of underutilised crops and hence suitability in local agroecological contexts.

The framework identifies five broad questions:

1. *What is the relationship between traditional crops, food heritage, landscapes and cultural and spiritual values, and which of these are threatened or lost?* What is the role of traditional crops, wild edibles and semi-cultivated crops in culture and spirituality, sustainability, food security, nutrition and resilience? What are the traditional methods for seed management, cultivation, improvement, processing, storage and food preparation?
2. *How are farming and forest food systems interconnected today and in the past?* How does this affect outcomes for risk management, food security, nutrition, biodiversity conservation, cultural and spiritual values and holistic well-being?
3. *How are biological and cultural heritage interconnected?* How are human farming/food systems, wild ecosystems (forests, mountains, rivers) and the sacred/spiritual realms interconnected in Indigenous worldviews, beliefs and practices?
4. *What tools and approaches are needed to protect Indigenous food systems and biocultural heritage (or "food-related biocultural heritage") and revitalise them as living heritage?* How can the Potato Park approach be adapted to different contexts?
5. *How can Indigenous agri-food histories contribute to local, national and global policy debates on agriculture, biodiversity, climate resilience and development?*

These questions seek a holistic understanding of food systems, linking crops and wild foods with cuisine, landscapes, cultural and spiritual values and material heritage. They

aim to better understand the relationship between food-related biodiversity and cultural heritage at the local level and to deliver tangible benefits for community livelihoods and rights by supporting practical tools, such as collectively governed biocultural territories and micro-enterprises, as well as policy advocacy.

Three interlinked "work packages" were identified to address the research questions:

(1) *Ethnobotany of farming and food systems:* The first question on traditional crops and wild foods could be explored through participatory transect walks in farmers' fields, home gardens and wild harvesting areas, involving community researchers, farmers and botanists, to record local and scientific names and traditional knowledge about plant uses. Indigenous community researchers can record data using specifically designed smartphone apps linked to community databases. After collection, the results can be analysed by community participants using Indigenous methods such as matrix ranking, for example, to identify wild plants to prioritise for food, gastronomy and medicine. Transects can also serve to assess the conservation status and trends in the abundance of wild foods (based on the memories of elders), and the results can be used to prepare maps of vulnerable species and conservation plans [41]. Focus group discussions can then be held to further explore research questions about traditional crops and wild foods and validate the findings. These should include elders, women, men and youth; and it may be best to limit them to about 5–7 people to stimulate discussion, and to hold them when neighbours usually gather. If further information is needed, semi-structured interviews could be conducted with elders, at convenient times. The discussions can be recorded by community researchers on smartphones in Indigenous languages and later transcribed and translated [41].

(2) *Oral histories of farm-forest food heritage* could then be conducted with key Indigenous knowledge holders to further explore threatened or lost heritage (research questions 1-3), building on the ethnobotanical information collected (e.g., using crop/plant lists with local, Indigenous and Latin names). Oral histories can be used to identify key moments of change (e.g., the Cultural Revolution in China, the emergence of protected areas in India, and agricultural modernisation campaigns in Kenya), and explore the situation before and after. This can create stories of change that can be shared more widely amongst communities and with policymakers. Unstructured oral histories, such as stories and songs of elders and women (e.g., while women are processing or cooking traditional foods), can provide insights into ancestral values and worldviews and bring out the meanings and emotions attached to threatened or lost heritage. Indigenous and archival sources may provide further detail, for example, on local cosmovision, crop varieties, food and farming systems, before key moments of change. Ethnobotanical information can also be compared with any existing regional archaeobotanical data to provide a deep-time view of crop histories [38,44].

(3) *Tools to protect and revitalise food-related biocultural heritage:* Key tools can be developed and tested, building on the Potato Park experience but adapting them to different biocultural and political contexts, such as mixed ethnic communities in sub-tropical and temperate mountain forests in northeast India; dispersed terraced mountain communities along the Jinsha river in Yunnan; and the densely populated semi-arid Rabai Kaya forest landscape near Mombasa. The following tools were identified by communities in the local workshops, reflecting key components of biocultural heritage territories:

- Collective governance institutions (building on customary governance).
- Micro-enterprises (e.g., agro-ecotourism, value addition, traditional restaurants).
- Tools to promote intergenerational TK transmission (e.g., revival of traditional Rome in Kenya, Biocultural Festivals, Farmer Field Schools, tailored outputs for schools).
- Awareness raising, for example through display panels on the findings for community museums and registration of food heritage as Intangible Cultural Heritage (in China).

The first step in any ethical research process should be an FPIC process where community members and authorities can deliberate on the proposed research and adapt/reframe the research objectives, questions and approach to reflect their own priorities, concepts and cosmovision, or deny consent. Several participants at the global workshop stressed the importance of FPIC to respect community rights and reduce power imbalances. In line with the Potato Park approach, community researchers are then selected by village authorities to design and conduct the research in each village and continue to work closely with these authorities to whom they are primarily accountable, ensuring a community-led process. Research design and training workshops are then held where the community researchers select or refine the research questions and identify appropriate Indigenous methods and tools and participatory methods. Local workshops are held to bring together participating communities to share and co-analyse the results and jointly plan activities for the following year, along with local annual biocultural festivals to disseminate the results, celebrate the food-related biocultural heritage and promote local government support.

5. Discussion

The global workshop showed that Indigenous Peoples' food systems in different regions sustain high levels of crop diversity and resilient varieties for climate adaptation, and provide nutritious diets through agroecological and sustainable practices, to meet the food security needs of communities and future generations. It also showed that traditional knowledge—not only farming and food practices but ancestral values, beliefs, rituals and worldviews associated with nature—are critical for the continuation of these food systems. The Quechua Potato Park communities stressed the importance of their holistic worldviews and core values of Solidarity, Reciprocity and Balance with nature in ensuring food security and biodiversity conservation. Research has found that the Naxi and Moso in China, Lepcha and Limbu in India and Mijikenda in Kenya have similar traditional core values of solidarity, reciprocity and balance with nature and in society, although these have become weaker [13].

The global and local workshops also provide evidence that the COVID-19 pandemic has had minimal impacts on the food security and health of Indigenous and traditional communities that maintain traditional food systems in the Cusco region of Peru, Rabai, coastal Kenya, Kalimpong, northeast India and Yunnan, southwest China. The communities attributed this to the medicinal and immune-boosting properties of traditional crops and medicinal plants, and to social cohesion associated with sacred seeds and traditional values of solidarity. The Potato Park communities donated a ton of potatoes to people in need in Cusco in line with their Solidarity values. The workshops showed the importance of wild foods for meeting nutrition and health needs in different cultures and ecosystems, and the role of home gardens in biodiversity conservation and nutrition (particularly in Asia). Traditional farmers experiment with wild varieties in home gardens in Asia, and use wild crop species to enrich domesticated crops and breed new resilient varieties in Asia, Peru and Kenya. Restricting customary forest use in northeast India has negatively impacted food security and weakened customary norms for sustainable use, while reducing productivity on-farm and promoting a shift to cash crops.

The evidence presented at the workshops is supported by a growing number of studies on the role of Indigenous food systems in sustainability, biodiversity conservation, food security, nutrition and climate resilience, including the FAO submission to the 2021 UN Food Systems Summit, and a High-Level Expert Seminar convened by FAO in 2018 [3,4,10]. A global assessment conducted by the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) in 2019 found that biodiversity is generally declining less rapidly on Indigenous Peoples' lands than on other lands [6]. Studies have shown that traditional farmers, pastoralists, fishers, hunters and gatherers typically conserve biodiversity through adaptive management based on traditional knowledge [15,45], using strong protocols and prohibitions against overharvesting and towards sustainable use [10]. Studies have also

shown that shifting cultivation does not contribute to deforestation or carbon emissions, and is important for sustaining agrobiodiversity, food security and cultural heritage [46,47].

The Intergovernmental Panel on Climate Change has identified the importance of Indigenous knowledge and worldviews for resilience and adaptation to climate change [48]. Studies show that Indigenous cultivation and use practices maintain and further evolve food-related biocultural diversity for local adaptation [7,49] and that Indigenous crop varieties and local landraces typically withstand stress (e.g., drought, pests and diseases) better than their modern equivalents, reducing the risk of crop failure in increasingly variable and extreme climates [9,49–51]. Indigenous farming systems also typically emit less carbon due to agroecological inputs and agroforestry practices [3,10]. Linking traditional and western knowledge can achieve optimum productivity and resilience in risk-prone areas [50].

Indigenous foods have been found to contain essential micronutrients lacking in regional diets (e.g., in NE India); while shifts to western diets are often associated with declining health and nutrition [10]. The neglected crop varieties that Indigenous Peoples cultivate are typically nutrient-dense, with higher nutritional value than modern varieties [10,11]. Wild seeds, nuts, fruits, leaves, bush-meat and fish remain a significant micronutrient source for millions of Indigenous and rural people worldwide [52]. Wild food plants tend to be richer in micronutrients than cultivated crops [52,53]. Research has found that people engaged in traditional activities in remote, biodiverse areas with little reliance on market economies tend to be of normal weight [10].

The global and local workshops show that Indigenous food systems across regions face multiple threats and are being rapidly eroded by policies that promote modern agriculture, food and education, industrial development and globalisation. Economic development and industrial agriculture have replaced traditional farming in many Asian communities, leading to rapid changes in food, diet and nutrition. In Kenya, hybrid seeds and agro-chemicals have been strongly promoted and policies are hard to change due to the links between government and agribusiness. Hunter-gatherers in Africa and Asia are seriously threatened by both development and protected areas, while the way of life of Arctic hunters and fishers in Russia has been almost destroyed by industrial development. Rotational farming and pastoralism are negatively perceived even though they are sustainable systems. Across these food systems, insecure rights to land and to self-determination are key underlying threats.

Lemke and Delormier (2017) note that "interference by State and corporate actors continues to dispossess Indigenous Peoples of their lands, resources and self-determination, violating their rights to adequate food and nutrition" [5]. They and other studies identify industrial agriculture as a key threat, driven by commercial interests. Strong biases against traditional biodiverse production systems persist, yet intensive high-input monocultures are vulnerable to climate risk and pests and diseases and are a key driver of biodiversity loss and environmental degradation [6]. Protected areas based on colonial conservation models have restricted traditional harvesting practices critical for food security and are not effectively or equitably managed, a global biodiversity assessment found [15].

Evidence from the workshops suggests that replacing traditional farming systems and crops with modern cash crops is leading to hidden losses for resilience, nutrition, health, culture and social cohesion. Significant global declines in agrobiodiversity over many decades is cause for alarm, narrowing the genetic base for food security and climate change adaptation [7]. This diversity is only partially safeguarded in ex situ gene banks, whose collections are no longer evolving in response to environmental and climatic change, unlike those in the field [7]. There are also identified risks and gaps in ex situ strategies for crop landraces, especially for some underutilised species [54]. Loss of biodiversity is likely to also contribute to the loss of related traditional knowledge and values, given the links between them [55]. The UN estimates that more than 20 Indigenous languages are lost each year and that 50–95% of the world's languages will be lost by 2100 [56]. The workshops suggest that the revival of Indigenous food systems and interlinked biological and cultural heritage is critical for responding to multiple crises associated with their decline (ecological,

cultural, climatic, food, health). The revitalisation of traditional farming systems can bring economic benefits that reverse the out-migration of youth, as in the case of the Karen rotational farming in northern Thailand.

Indigenous participants at the global workshop called for research that focuses on the challenges facing Indigenous Peoples and food systems. They highlighted three key issues for research: the rapid loss of Indigenous knowledge; Indigenous Peoples' land rights; and the impacts of industrial agriculture on Indigenous food systems. They emphasised the importance of Indigenous-led and decolonising research approaches to fully understand Indigenous food systems and reverse their loss. Research should be guided by Indigenous learning and holistic wellbeing concepts and should use Indigenous methods (e.g., story-telling, participatory mapping and transects, matrix ranking and collective analysis to identify practical actions). Community researchers in the local workshops called for research to generate livelihood benefits. Key ethical practices include seeking collective and individual FPIC and employing community researchers to take the lead in research design and implementation and work closely with Indigenous authorities to ensure a community-led approach. FPIC is a key ethical principle, enshrined in the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). Indigenous-led research can be supported by research inputs from western disciplines based on respectful collaboration. Historical approaches can support community efforts to revitalise Indigenous food systems which have already undergone changes in many cases, such as oral histories that support oral traditions.

Taking a decolonial approach means integrating how cultures approach conservation and development based on their own traditional experience and cosmovision and using their own cultural concepts and objectives as the goal of the research [40]. Research has shown that the Mijikenda in Kenya, Lepcha and Limbu in India and Naxi in China have similar holistic well-being concepts as the Quechua Sumaq Kausay and Ayllu concepts, that centre on the need for balance and reciprocity between the human, the wild and the sacred and ancestral worlds [13]. For example, the Rabai Kaya elders' understanding of well-being is founded on the Mudzini concept, which recognises sacred elements and symbols representing spirits, wild plants, humans, and domesticated plants and animals, and their interactions within the landscape, emphasising the harmonious relationship between humans and nature [57]. These Indigenous concepts can be used to adapt the methodological framework to local biocultural contexts.

A growing body of literature has emerged on decolonising and Indigenous research methodologies, which challenge existing approaches that have brought few benefits to Indigenous Peoples but have subjected them to multiple harms [5,21,23,24]. Chilisa (2011) argues that dominant Euro-Western research approaches represent a form of colonialism, since researchers use external theories and methods, collect information, do the analysis and interpret the findings to create generalisable theories, which are then used to inform further research [21]. Even if Indigenous knowledge is recorded it is not used to define the research problem, theories, concepts, methods and interpret the findings, so the process reinforces external values and perceptions of reality, of what is true, what counts as knowledge and what knowledge is important. Social science methods that originated in the west have become universal and this is "stripping marginalised groups of their ancestral culture and replacing it with Euro-Western culture". Instead, research should give space to the worldviews and frames of reference of those who have suffered a history of oppression and marginalisation, which emphasise relationships amongst living beings (humans, animals, etc.) and with the non-living.

In the Potato Park decolonising action-research approach, developed with Quechua communities with support from Asociacion ANDES, community researchers identify the research questions and methods and facilitate the research [41]. For example, the Potato Park communities decided to conduct research to document the resilience of their food systems. The community researchers gathered all data through a community survey. Survey questions were pre-approved by community members, who suggested the majority of them, and the surveys were conducted in Quechua [58]. "This community-driven approach

is important because it increases ownership of the results by communities, while researcher-driven approaches are often ineffective and inefficient. It establishes an inter-community network of researchers and creates employment in Indigenous communities" [59]. Indigenous conceptual frameworks such as biocultural heritage and Sumaq Kausay/Ayllu and decolonising methods can also enable a better understanding of food-related biocultural heritage than western concepts and approaches because they are based on an existing in-depth understanding of this heritage and are holistic and interdisciplinary. Experience in the Potato Park shows that orally based research using smartphones and tablets can offer reliable data collection methods and enable cross-language use in data collection and analysis rather than using only dominant colonial languages [60]. Elders' stories and Indigenous languages play an important role in maintaining knowledge about biocultural heritage [58,60].

According to Chilisa (2011), decolonising approaches can be integrative, combining western and Indigenous theories, but in their most advanced form, assumptions about what counts as reality, knowledge and values are informed by an Indigenous research paradigm [21]. Lemke and Delormier (2017) propose that ethical research with Indigenous Peoples should be guided by principles of "respect, responsibility and relationships" [5]. They note that the co-creation of knowledge founded in recognition of the strengths of both Indigenous and Euro-Western ways of knowing can contribute to creating new ways of knowing regarding Indigenous Peoples' food systems. They and others caution that "integration" of knowledge systems often results in "mining" Indigenous knowledge for western science, whereas "bridging" knowledge systems can respect the integrity of each one.

Virtanen (2019) notes that even if a decolonising approach is used in the documentation of traditional ecological knowledge, "individual research projects are limited in what they can succeed in doing about Indigenous cultural heritage and territorial protection" [34]. The work of ANDES (Peru) and the Potato Park shows that individual research projects can contribute significantly to heritage revitalisation and territorial protection, when Indigenous Peoples play a leading role and an action-oriented approach is taken, that strengthens local capacity and institutions and contributes to strategic processes to secure rights to land and self-determination, such as the establishment of biocultural heritage territories [40,41].

Although the local workshops did not allow sufficiently in-depth discussions to identify specific research questions, methods and tools with communities, they enabled a good understanding of the challenges to be addressed and ways forward. The live-streamed sessions allowed Indigenous Peoples to showcase their vast knowledge of food-related biocultural heritage through inclusive dialogues from their communities. The workshops showed that, when Indigenous Peoples play central roles as presenters and experts, virtual formats can enable meaningful intercultural dialogue and be a power-equalising force that can shift perspectives regarding traditional knowledge. Several community members (including women and youth) can participate directly in discussions from their own community/landscape, at a relatively low cost and respond to external questions (in contrast to pre-recorded video formats). The virtual format enabled many more Indigenous representatives and academics to participate in the global workshop than would otherwise have been possible.

6. Conclusions

Indigenous Peoples' food systems play vital roles in agrobiodiversity conservation, climate resilience, food security and nutrition. They sustain high levels of resilient Indigenous crops and landraces, which are continuing to evolve and co-evolve in response to climate change unlike those in gene banks, thus providing vital genetic reserves for climate resilience and adaptation locally and globally. Indigenous food systems have also proved resilient during COVID-19, ensuring food security and health in a range of contexts, from the Potato Park in Peru, to India, Kenya and China. However, their importance is widely overlooked, with Indigenous crops and knowledge being rapidly lost in favour of "modern" crops and practices. In fact, Indigenous and traditional crops and knowledge are not

"old" but are continually evolving and adapting to change through experimentation and the use of wild crops to enhance the resilience of domesticated varieties. Cultural values and worldviews and spiritual beliefs underpin the continuation of resilient Indigenous food systems.

Indigenous and traditional food systems face multiple threats from industrial agriculture, development, modern education and outmigration—which often affect both biodiversity and culture and are likely to be mutually reinforcing given the links between them. The inextricable linkages between biodiversity and cultural heritage as perceived by Indigenous Peoples should be reflected in definitions of Indigenous food heritage and biocultural heritage, to avoid marginalising Indigenous cosmovision and develop effective responses for their protection. There is an urgent need to protect and revitalise Indigenous food systems and biocultural heritage in a context of growing climatic risk and uncertainty, increasingly uniform and unsustainable agri-food systems, growing food insecurity, rising non-communicable diseases associated with modern diets, and rapid loss of Indigenous agroecological knowledge [3,4,10]. Lessons from Indigenous food systems can contribute to the resilience and sustainability of food systems worldwide, while supporting the wellbeing of Indigenous Peoples [3].

Further research is needed to address the myths and misunderstandings relating to Indigenous food systems, counter dominant narratives which view them as backward and environmentally damaging and promote the mainstreaming of traditional knowledge in agricultural policies. Research should be equitable and decolonial and should address Indigenous Peoples' needs by supporting Indigenous leadership and research methods, rather than using conventional methods which have marginalised Indigenous knowledge. It should be action-oriented, supporting practical initiatives to strengthen rights to land and self-determination, and should focus on whole food systems from farm to plate to effectively protect threatened heritage. FPIC is a key ethical principle for respecting Indigenous Peoples' rights that should be integral to all research projects, as well as to all policies and programs that affect Indigenous Peoples, in accordance with UNDRIP.

As the Potato Park experience shows, decolonising action-research and collective biocultural heritage territories can revitalise Indigenous food systems, protect in situ gene banks, strengthen local capacity to defend rights and help to build social movements to resist threats and promote change. External researchers can play useful support roles through respectful partnerships and should commit to becoming political activists, getting the voices of Indigenous Peoples heard and promoting social transformation [21].

Biocultural heritage territories are landscape approaches for in situ conservation that protect the many interlinkages between wild ecosystems and cultivated areas that support food and nutrition security, climate adaptation, spiritual and ecological values. The Potato Park model has been validated through scaling out to establish the Barter-Maize Park in Cusco, Peru [41]. Emerging experience suggests that the approach can and should be scaled out to different biocultural and political contexts in Rabai, Kenya, Northeast India and Yunnan China, but needs to be adapted through culturally centred, community-led processes. A key challenge to establishing biocultural territories in these contexts is that, unlike in Latin America, decolonial and Indigenous movements are weak and the rights of Indigenous and traditional peoples are often poorly recognised.

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